

FROM: HQ AFCESA/CES  
139 Barnes Drive, Suite 1  
Tyndall AFB, FL 32403-5319

**SUBJECT: Engineer Technical Letter (ETL) 98-X: Resin Modified Pavement (RMP) Design and Applications Criteria**

**1. Purpose.** This ETL provides guidance to help the Base Civil Engineer (BCE) and other users in the design and maintenance of resin modified pavements (RMP).

**2. Application:**

**2.1.** The RMP is a pavement surfacing technology that may be used in practically any pavement application and environment. The only exception to this is airfield runway pavements, since there is no experience on runways to validate performance or durability in these circumstances.

**2.2. Effective Date:** Immediately. Expires five years from date of issue.

**3. Referenced Publications.**

**3.1.** MP GL-96-7, *User's Guide: Resin Modified Pavement*, U.S. Army Engineer Waterways Experiment Station, Vicksburg, MS.

**3.2.** ETL 1110-1-177, *Engineering and Design - Use of Resin Modified Pavement*.

**3.3.** AFM 88-7 CH1, *Pavement Design for Roads, Streets, Walks, and Open Storage Areas*.

**3.4.** AFM 88-6 CH2, *Flexible Pavement Design for Airfields (Elastic Layered Method)*.

**3.5.** CEGS-02746, *Guide Specification for Military Construction - Resin Modified Pavement*.

**3.6.** CEGS-02760, *Guide Specification for Military Construction - Field Molded Sealants for Sealing Joints in Rigid Pavements*

**3.7.** CEGS-02975, *Guide Specification for Military Construction - Sealing of Cracks in Bituminous Pavements*.

**3.8.** CEGS-02981, *Guide Specification for Military Construction - Grooving for Airfield Pavements*.

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**3.9.** ASTM D1190, *Concrete Joint Sealer, Hot-Applied Elastic Type*, American Society for Testing and Materials, Vol. 04.03, Philadelphia, PA.

**3.10.** ASTM D3405, *Joint Sealants, Hot-Applied, for Concrete and Asphalt Pavements*, American Society for Testing and Materials, Vol. 04.03, Philadelphia, PA.

**3.11.** ASTM D3569, *Joint Sealant, Hot-Applied, Elastomeric, Jet-Fuel-Resistant-Type for Portland Cement Concrete Pavements*, Vol. 04.03, Philadelphia, PA.

**3.12.** ASTM D3581, *Joint Sealant, Hot-Poured, Jet-Fuel-Resistant Type, for Portland Cement Concrete and Tar-Concrete Pavements*, Vol. 04.03, Philadelphia, PA.

#### **4. Specific Requirements.**

**4.1. Areas of Application.** Resin modified pavement (RMP) may be used for virtually any road or airfield pavement application except for runway pavements. RMP has been field-proven to resist damage from fuel spillage and other liquid solvents due to its relatively low permeability when compared to asphalt concrete and portland cement concrete. It has also been proven to be resistant to damage from tracked vehicles, vehicles with solid rubber tires, and resistant to rutting and other deformation distresses resulting from various combinations of high tire pressures, channelized traffic and high pavement temperatures. An RMP surfacing may be placed over a properly-designed flexible pavement structure, with at least 50-mm of dense-graded asphalt concrete placed underneath the RMP layer. RMP may be used as the overlay surfacing when rehabilitating either flexible pavements or pavements with asphalt concrete over portland cement concrete.

A general description of the RMP technology is given in the report MP GL-96-7, "User's Guide: Resin Modified Pavement." Mix design and quality control testing guidance for RMP is provided in ETL 1110-1-177, "Engineer and Design - Use of Resin Modified Pavement." Finally, the user is directed to CEGS-02746 "Guide Specification for Military Construction - Resin Modified Pavement" for a model specification on RMP materials, construction, and testing requirements.

**4.2. Life Cycle Costs:** The following cost data are provided, based on limited bid documents and maintenance records from previous RMP applications in the United States:

Unit Cost for Construction of Typical 50-mm-thick RMP Layer: **\$18 - 24 / sq m**

When RMP is placed over jointed portland cement concrete (JPCC) and matching joints are cut in RMP, add **\$6.00 / sq m** (based on 20-yr pavement life, initial and 5-yr cycle joint sealing and resealing, 5-m square JPCC slabs, \$1.15 / LF for joint sealing and resealing).

When RMP is placed over JPCC (at any depth below pavement surface), and RMP surfacing is allowed to reflective crack naturally, add **\$3.25 / sq m** (based on 20-

yr pavement life, 5-m square slabs, 50% reflective cracking at 10 yrs costing \$2.50 / LF to rout and seal, 75% reflective cracking at 15 yrs costing \$2.50 to rout and seal plus \$1.15 to reseal existing cracks).

When RMP is placed over structurally sound flexible pavement substructure (including rubberized or cracked and sealed PCC), no additional maintenance costs are expected for a 20-yr design life.

**4.3. Structural Design Criteria:** Attachment 1 provides structural design criteria specific to RMP designs. An airfield pavement design example is given to demonstrate this procedure. The general design approach is to use the elastic layered method for flexible pavements along with the specific material properties of RMP as detailed in Attachment 1.

**4.4. Repair and Maintenance Techniques:** Attachment 2 provides guidance on possible repair and maintenance techniques for RMP. Maintenance in this regard includes possible joint and crack sealing, spot repairs, and surface grooving.

**5. Points of Contact:** Dr. Gary L. Anderton  
U.S. Army Engineer Waterways Experiment Station  
3909 Halls Ferry Road  
Vicksburg, MS 39180  
Attn: CEWES-GP-Q  
telephone: 601-634-2955  
fax: 601-634-3020  
e-mail: andertg@ex1.wes.army.mil.

Mr. James L. Greene  
AFCEA/CESC  
139 Barnes Drive, Suite 1  
Tyndall AFB FL 32403  
Telephone: (850)283-6334  
FAX: (850)283-6499  
Email: greenej@afcesa.af.mil

Lance C. Brendel, Colonel, USAF  
Director of Technical Support

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1. Structural Design Criteria for Resin Modified Pavement (RMP)
2. Repair and Maintenance Techniques for Resin Modified

## Pavements (RMP)

### Structural Design Criteria for Resin Modified Pavement (RMP)

For pavement designs other than airfields, RMP is to be designed using guidance provided in AFM 88-7, Chapter 1, "Pavement Design for Roads, Streets, Walks, and Open Storage Areas." In these cases, the RMP thickness (generally 40-60 mm) is considered equivalent to the same thickness of asphalt concrete surfacing. The pavement is designed as if it were going to be a traditional asphalt concrete surfaced flexible pavement, and then the RMP thickness is used to replace an equivalent thickness of the top layer of asphalt concrete. A minimum thickness of 50 mm of asphalt concrete is required beneath the RMP surfacing. When the combined RMP and asphalt concrete thickness exceeds the design thickness of asphalt concrete surfacing in the traditional flexible pavement design, then standard asphalt concrete equivalency factors may be used to reduce base or subbase thickness. An example of such a design conversion is shown in Figure 1.1.

(a)		(b)	
<hr/>		<hr/>	
<b>Asphalt Concrete</b>	75 mm	<b>RMP</b>	50 mm
<hr/>		<hr/>	
		<b>Asphalt Concrete</b>	50 mm
<hr/>		<hr/>	
<b>Base</b>	150 mm	<b>Base</b>	122 mm
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<b>Subbase</b>	150 mm	<b>Subbase</b>	150 mm
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<b>Subgrade</b>		<b>Subgrade</b>	

Figure 1.1. Conversion of traditional asphalt concrete surfaced road design (a) to an equivalent RMP surfaced road design (b)

Resin modified pavements on airfields are designed using the existing elastic layered method for flexible pavements as prescribed in AFM 88-6, Chapter 2, “Flexible Pavement Design for Airfields (Elastic Layered Method).” The RMP layer is added to the top of a traditional flexible pavement design, with a minimum of 50 mm of asphalt concrete underneath and fully-bonded to the RMP layer. The modulus of the RMP is temperature-dependent and is estimated from the graphical relationship given in Figure 1.2. Poisson’s ratio of RMP is considered to be uniform at all normal pavement temperatures, with a value of 0.27 recommended for design.

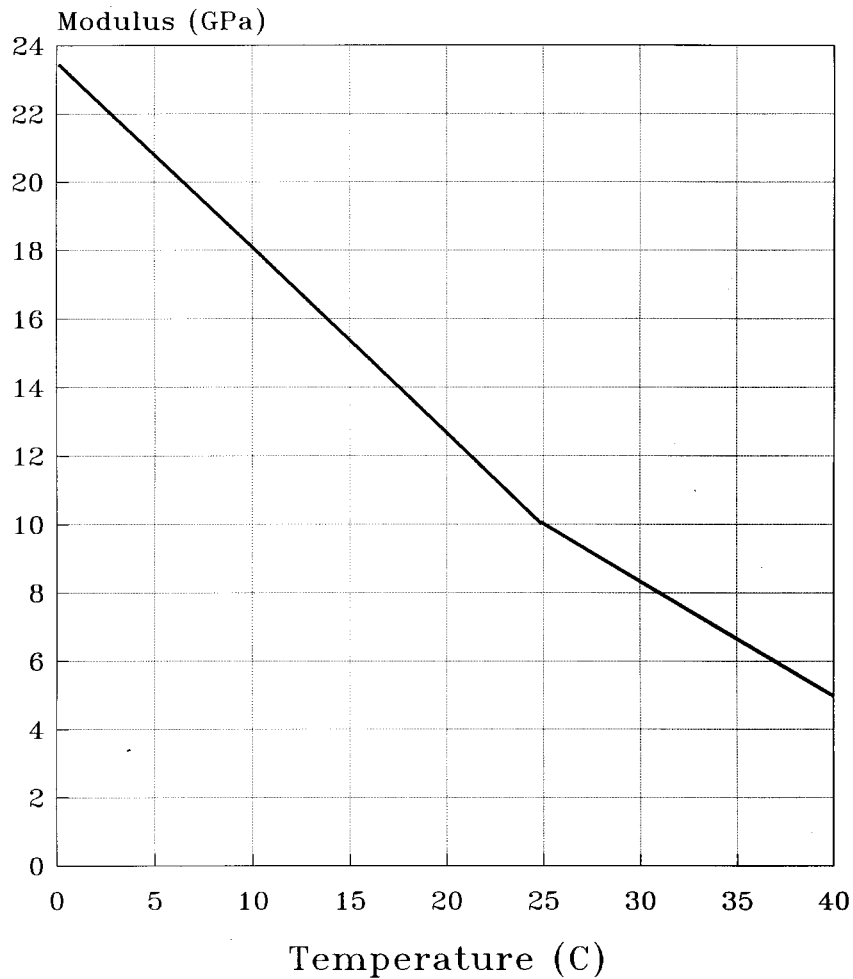


Figure 1.2. RMP resilient modulus versus temperature design curve

The critical failure points for an RMP design are the same as those that control a traditional asphalt concrete surfaced flexible pavement: excess vertical (compressive) strain on top of the subgrade and excess horizontal (tensile) strain at the bottom of the asphalt concrete layer. Research has shown that pavement failure should occur at these points before excessive tensile strains at the bottom of the RMP layer cause cracking to occur in the surface layer. Nevertheless, fatigue curves have been generated for RMP materials in the strain range and cycles-to-failure range common for typical airfield pavements. These fatigue curves cover a full range of pavement temperatures and are shown in Figure 1.3. Using the calculated strains at the bottom of the RMP layer for a given design scenario with the appropriate fatigue curve (interpolated between temperatures if necessary) gives the estimated number of allowable aircraft passes. Noting the strain range of the RMP fatigue curves, it can be said that strains in the RMP layer at or above the  $10^{-3}$  level are likely to cause very quick failures and strains at or below the  $10^{-5}$  level are negligible in terms of fatigue damage to the RMP layer.

The typical RMP airfield pavement design will include the following general design steps as a minimum:

- 1) Determine design aircraft loads and tire pressures, as well as the design's required number of aircraft passes for the pavement's design life.
- 2) Determine pavement material properties, including subgrade CBR, asphalt concrete modulus versus temperature relationship, and each pavement layer's cost and availability.
- 3) Gather historical temperature data for the site in order to assign seasonal modulus values to the asphalt concrete and possibly the subgrade layers.
- 4) Determine total pavement thickness required for design aircraft and subgrade CBR from appropriate aircraft design curves found in AFM 88-6, Chapter 2. Also determine minimum surface layer and base course thickness from standard requirements for given pavement design.
- 5) Create an initial pavement design section based on the following:
  - a. Top 40- to 60-mm-thick layer is RMP with modulus based on seasonal average pavement temperature and Poisson's ratio of 0.27.
  - b. Remaining amount of required pavement surfacing thickness is asphalt concrete, which is fully-bonded to the overlying RMP layer. The minimum thickness of this asphalt concrete layer is 50 mm. Modulus and Poisson's ratio of asphalt concrete are relative to seasonal pavement temperature or other acceptable standard value used by the design agency.
  - c. Base course layer should begin at minimum thickness required for the given pavement type. Modulus and Poisson's ratio for this layer are usually standard values prescribed by AFM 88-6, Chapter 2, unless other test data on the base course materials suggest otherwise.
  - d. The remaining pavement thickness required by the subgrade CBR criteria shall be a subgrade material, if available. Use modulus and Poisson's ratio values prescribed by AFM 88-6, Chapter 2 unless available material test data is considered to be more valid.

- 6) Conduct layered elastic design analysis in typical fashion (normally by computer program). Observe calculated strains and resulting number of allowed aircraft passes ( $N$ ) versus the required number of aircraft passes ( $n$ ) for a given season. The value of  $n/N$  is computed for each aircraft used in the design and summed to obtain the cumulative damage factor ( $\sum n/N$ ).
- 7) The assumed pavement layer thicknesses are adjusted until the cumulative damage factor (CDF) equals or is as slightly below 1.0 as possible. When pavement profile constraints and pavement material costs are considered in obtaining the design section whose CDF is at or very close to 1.0, then the optimum RMP structural design is given.

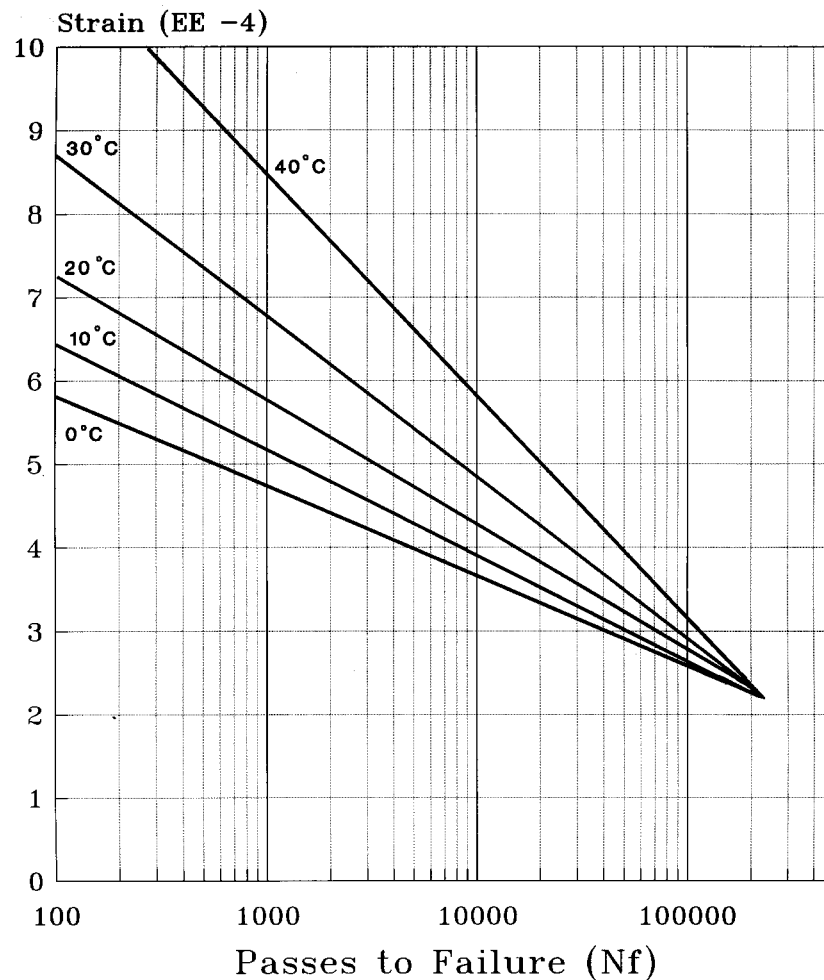


Figure 1.3. RMP fatigue design curves at various pavement temperatures



## RMP Airfield Pavement Design Example

A hypothetical RMP airfield apron design example is presented here to demonstrate the RMP Layered Elastic Design Method. The BISAR computer code developed for layered elastic design of flexible pavements is used to compute strains at the bottom of the RMP and asphalt concrete layers as well as at the top of the subgrade. Non-SI (English) units are used with the data for this example since the current BISAR computer program is designed for these units.

*Step 1: Traffic Data.* The airfield site is assumed to be in Shreveport, Louisiana where an airfield apron is to be designed for 200,000 passes of a C-130 aircraft with a design load of 155,000 lb.

*Step 2: Material Properties.* Modulus values for the subgrade, subbase, and base materials are assumed to be 10,000 psi, 25,000 psi, and 50,000 psi, respectively. Subgrade CBR is assumed to be 6 and base CBR is assumed to be 80. The asphalt concrete (AC) to be used at this site was tested and has a modulus versus temperature relationship as shown in Figure 1.4. Standard Poisson's ratios for the AC, granular base, subbase, and cohesive subgrade are 0.35, 0.30, 0.30, and 0.40, respectively. AC materials are assumed to cost more than base materials, which are in turn assumed to cost more than subbase materials.

*Step 3: Historical Temperature Data.* From the climatic data of this site, the design pavement temperature is obtained and the design AC modulus values are determined as shown in Table 1.1. To reduce the number of computations, the 12 month groups are reduced to four seasonal groups as shown in Table 1.2.

*Step 4: Estimate Total Pavement Thickness.* By using the appropriate aircraft design curve found in AFM 88-6, Chap. 2, the total thickness of pavement required for the design aircraft and the 6 CBR subgrade is estimated to be approximately 28 in. U.S. Air Force standards (AFM 88-6, Chap. 2, Table 6.3) require a minimum AC thickness of 4-in. and a minimum base course thickness of 6-in. for a medium load design, Type B traffic area, and an 80-CBR base material.

*Step 5: Initial Pavement Design Section.* The initial design section is as follows: 2-in. of RMP; 2-in. of AC; 6-in. of base; 18-in. of subbase. This would likely represent the most economical design section and if any added strength would be required, then replacement of subbase material with base material would be the first logical choice. If the design analysis showed that this pavement thickness was over-conservative because of the added structural capacity of the RMP layer, then subbase thickness could be reduced to make the optimum final design more economical.

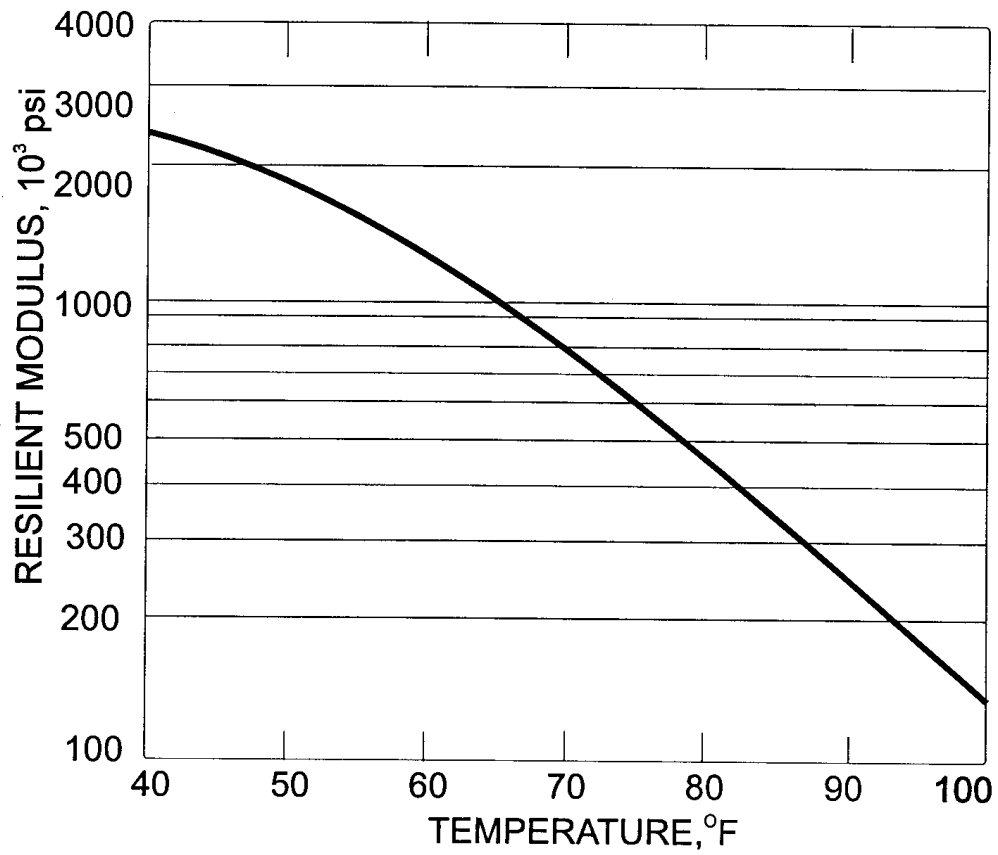


Figure 1.4: Temperature-modulus relationship for design example AC

Table 1.1: Monthly Design Pavement Temperatures and AC Moduli
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Month	Pavement Design Temperature (°F)	Resilient Modulus ( $10^3$ psi)
Jan	56	1500
Feb	60	1270
Mar	67	920
Apr	76	570
May	84	360
Jun	92	220
Jul	95	180
Aug	95	180
Sep	89	260
Oct	77	540
Nov	65	1000
Dec	57	1400

Table 1.2: Grouping Traffic into Seasonal Traffic Groups					
Group	Month	Resilient Modulus ( $10^3$ psi)		Percent of Total Traffic	Group Required Passes ( $n_{reqd}$ )
		Monthly Value	Group Average		
1	Jan	1500			
	Dec	1400	1390	25.0	50,000
	Feb	1270			
2	Nov	1000			
	Mar	920	960	16.7	33,400
3	Apr	570			
	Oct	540	490	25.0	50,000
	May	360			
4	Sep	260			
	Jun	220			
	Jul	180	210	33.3	66,600
	Aug	180			

*Step 6: Layered Elastic Design Analysis of Initial Design Section.* The flexible pavement elastic layer design computer program is used to calculate strains at the critical locations, allowable passes, and damage factors for the initial RMP design section. Traffic is assumed to be evenly distributed throughout the year and is therefore weighted for each season based on the number of months in the particular season. Modulus values of the RMP and AC layers are assigned based on each season's average pavement temperature and the relationships given in Figures 1.2 and 1.4. One computer analysis is made for each of the four climatic seasons to predict the ability of the initial RMP design section to carry the required traffic during each season. The computer code calculates allowable passes for subgrade and AC failure criteria, but the number of passes allowed by the calculated strains at the bottom of the RMP layer must be determined from the fatigue curves provided in Figure 1.3. Interpolation between these curves may be necessary for accurate interpretation at specific pavement temperatures. A summary of the design inputs, calculated strains, and seasonal damage factors is given in Table 1.3. Seasonal damage factors are used in this simplified example since only one aircraft is used for the design, which negates the need for cumulative damage factors.

The results of this design analysis indicate that the initial design section would fail prematurely under the given conditions as a result of tensile cracking initiated at the bottom of the AC layer. These cracks would likely propagate upwards into the RMP layer rather quickly since the RMP and AC layers are assumed to be fully-bonded. This type of pavement failure is considered to be the most common type resulting from an inadequate pavement structure when considering RMP designs.

*Step 7: Use of Calculated Strains, Allowable Passes and Seasonal Damage Factors to Determine Optimum RMP Design Section:* The optimum RMP design section is determined by trial-and error computer analyses of various structural profiles. The optimum design in this design example represents the most economical structural profile (minimum allowable AC and base course thickness) that provides enough allowable passes (N) to just exceed the required number of passes (n) in each of the four climatic seasons. Damage factors ( $n/N$ ) must be equal to or less than 1.0 for each failure point (bottom of RMP, bottom of AC, top of subgrade) and for each season to satisfy this design approach. A summary of the structural layer input data, calculated strains, and damage factors for the optimum RMP design is given in Table 1.4.

For this design example, an additional 2-in. of AC and 8-in. of base course were added to the initial design section with an equivalent 10-in. reduction in subbase thickness to arrive at the optimum RMP design section. This optimum design provides just enough structural capacity to protect the AC layer from premature cracking during the Group 3 and Group 4 seasons.

Table 1.3: Summary of Initial RMP Design					
Pavement Layer	Thickness (in.)	Seasonal Modulus Values ( $10^3$ psi)			
		Group 1	Group 2	Group 3	Group 4
RMP	2	2100	1775	1450	980
AC	2	1390	960	490	210
Base	6	50	50	50	50
Subbase	18	25	25	25	25
Subgrade	----	10	10	10	10
$n_{reqd}$		50,000	33,400	50,000	66,600
RMP Strain		$5.42 \times 10^{-6}$	$1.47 \times 10^{-5}$	$3.94 \times 10^{-5}$	$5.39 \times 10^{-5}$
RMP $N_{allow}$		Infinite	Infinite	Infinite	Infinite
RMP $n/N$		near 0	near 0	near 0	near 0
AC Strain		$2.24 \times 10^{-4}$	$6.77 \times 10^{-5}$	$6.34 \times 10^{-5}$	$4.41 \times 10^{-5}$
AC $N_{allow}$		33,624	29,510	22,317	47,343
AC $n/N^*$		1.49*	1.13*	2.24*	1.41*
Subgrade Strain		$7.89 \times 10^{-4}$	$8.17 \times 10^{-4}$	$8.54 \times 10^{-4}$	$9.02 \times 10^{-4}$
Subgrade $N_{allow}$		1,485,842	1,055,594	609,167	328,519
Subgrade $n/N$		0.03	0.03	0.08	0.20
* Indicates premature failure in AC layer for all seasonal groups.					

Table 1.4: Summary of Optimum RMP Design					
Pavement Layer	Thickness (in.)	Seasonal Modulus Values ( $10^3$ psi)			
		Group 1	Group 2	Group 3	Group 4
RMP	2	2100	1775	1450	980
AC	4	1390	960	490	210
Base	14	50	50	50	50
Subbase	8	25	25	25	25
Subgrade	----	10	10	10	10
$n_{reqd}$		50,000	33,400	50,000	66,600
RMP Strain*		$6.83 \times 10^{-6}$	$4.32 \times 10^{-5}$	$-5.37 \times 10^{-6}$	$-6.47 \times 10^{-6}$
RMP $N_{allow}$		Infinite	Infinite	Infinite	Infinite
RMP $n/N$		near 0	near 0	near 0	near 0
AC Strain		$1.85 \times 10^{-6}$	$2.14 \times 10^{-4}$	$2.69 \times 10^{-4}$	$3.18 \times 10^{-4}$
AC $N_{allow}$		134,003	100,398	54,844	67,828
AC $n/N$		0.37	0.33	0.91	0.98
Subgrade Strain		$6.32 \times 10^{-4}$	$6.68 \times 10^{-4}$	$7.21 \times 10^{-4}$	$7.91 \times 10^{-4}$
Subgrade $N_{allow}$		Infinite	Infinite	Infinite	Infinite
Subgrade $n/N$		near 0	near 0	near 0	near 0
* Negative strain values indicate compression.					

## **Repair and Maintenance Techniques for Resin Modified Pavement (RMP)**

Possible repair and maintenance techniques for existing RMP areas include joint and crack sealing, patching, and transverse grooving. These pavement repair and maintenance techniques generally involve methods similar to those used for traditional asphalt concrete (AC) and portland cement concrete (PCC) pavement surfacings. Guidance particular to RMP applications and the pertinent document references are provided below.

### **Joint Sealing**

Joint sealing materials and methodologies generally follow the established guidance for AC and PCC pavement surfacings. Expansion or separation joints are required between RMP and adjacent PCC pavements. The joint is first saw cut to a minimum depth equal to the maximum thickness of RMP. This initial saw cut should be made 1 to 5 days after grouting the RMP. A joint sealant reservoir is then cut as soon as possible using standard size and geometry relative to traditional PCC contraction or expansion joints, depending upon the pavement's location. Construction of the joints should follow the guidelines specified by the Corps of Engineers Guide Specification CEGS-02760, "Field Molded Sealants for Sealing Joints in Rigid Pavements."

Typically, RMP joints are filled with approved, asphalt-based sealant materials meeting the requirements specified by ASTM D1190 "Concrete Joint Sealer, Hot-Applied Elastic Type" or ASTM D3405 "Joint Sealants, Hot-Applied, for Concrete and Asphalt Pavements." If improved joint sealant fuel-resistance is desired, then the Dow Corning 890 SL asphalt-compatible silicone sealant may be used. For even better fuel-resistance, approved coal tar-based sealants are used. Coal tar joint sealants must meet the requirements of ASTM D3569 "Joint Sealant, Hot-Applied, Elastomeric, Jet-Fuel-Resistant-Type for Portland Cement Concrete Pavements" or ASTM D3581 "Joint Sealant, Hot-Poured, Jet-Fuel-Resistant Type for Portland Cement Concrete and Tar-Concrete Pavements."

### **Crack Sealing**

Sealing cracks in RMP surfacings is similar to sealing cracks in AC and PCC pavements. In general, cracks in RMP have been found to ravel open at a lesser rate than cracks in AC and PCC pavement surfacings. Unless fuel-spillage in the cracked RMP area is a particular concern, cracks less than 5-mm-wide should not be sealed. Cracks larger than 5-mm-wide should be sealed, as needed, based on the pavement's use and traffic considerations.

The same sealant materials previously prescribed for joint sealing should be used for sealing cracks in RMP. An additional choice for a crack sealing material is a modified version of the same grout material used to construct the RMP. The use of this grout as a crack filler should be limited to situations where crack movement has virtually stopped since the hardened grout filling the crack will be relatively stiff when compared to the traditional asphalt-based or silicone-based joint and crack sealing materials. It will,

however, give a more uniform appearance to the repaired RMP surfacing and likely last much longer, assuming no further crack movements. Regardless of the crack sealer material being used, the crack should be cleaned (and routed if necessary) according to the guidance found in the Corps of Engineers Guide Specification CEGS-02975, “Sealing of Cracks in Bituminous Pavements.”

Table 2.1: Grout Formulation for RMP Crack Sealing	
MATERIAL	BATCH WEIGHT PERCENTAGE (%)
Portland Cement	23
Class F Fly Ash	39
Silica Sand	7
Water	18
PL7 Resin	13

The grout formulation to be used for crack sealing is given in Table 2.1. The materials used in the grout for crack sealing must meet all of the physical requirements specified by the Corps of Engineers Guide Specification CEGS-02746, “Resin Modified Pavement.” The grout materials should be mixed in either a rotary blender or a small portable concrete batch mixer according to the sequence and mixing time guidelines prescribed by ETL 1110-1-177, “Engineering and Design - Use of Resin Modified Pavement.” These mixing guidelines generally call for high-speed mixing of the portland cement, fly ash, sand, and water for five minutes, adding the PL7 resin, then mixing at high speed for an additional three minutes.

Application of the modified grout into a cleaned RMP crack is best accomplished by carefully pouring the material into the crack by hand, as shown in Figure 2.1. Use of a small container that can be capped allows for the grout to be shaken occasionally during the application process. This helps ensure a consistent grout material throughout the application of a particular batch. The crack should be filled flush to the surface or to a level within 3 mm of the surface. Accidental over-fills may be brushed flush to the surface level with a wet paint brush.





Figure 2.1 Applying modified grout to seal RMP crack

## Patching

Isolated patching of RMP may be required for a number of reasons, including repair of utility cuts, concentrated failures in the pavement surfacing, or concentrated failures in the pavement's subsurface layers. These isolated pavement failures can be caused by improper materials or construction techniques, localized weakening in the pavement subsurface layers, expansive clays, or frost-heave damage.

Removing the RMP surface layers can be accomplished by one of two methods: milling or sawing and breaking. Pavement removal by a rotary-type cold milling machine is the method of choice when only the RMP layer is to be removed, as this method allows for pavement removal at precise depths. When a milling machine is not available or when the depth of desired pavement removal is deeper than practical for the milling machine, then the sawing and breaking method should be used. A water-cooled, concrete saw is used to outline the area of pavement to be removed. The saw cuts will normally be made to the bottom of the underlying AC layer since the RMP and AC layers are expected to be fully bonded by a tack coat. The RMP and AC layers can then be broken up by pneumatic drills, pneumatic hammers, or other hand tools before removing the damaged material. If pavement subsurface layers are removed or disturbed, then each layer must be replaced or reconstructed to meet all applicable specifications used in the original construction.

Ideally, it is best to use the same type of materials removed from a pavement patch when placing repair materials back into the patch area. This provides uniformity in and around the patch area. However, using the same original pavement material type is not always practical from an availability or economic standpoint. It is for this reason that two types of pavement materials are allowed when resurfacing RMP patches: 1) RMP over AC, and 2) traditional PCC materials. The PCC material option is not allowed, however, when the patch surface area is greater than 6 sq m.

When only the RMP layer is removed, RMP material must be used to replace this surfacing since traditional PCC materials are not effective surfacings when placed at very shallow depths. A light coating of bituminous emulsion should be sprayed or brushed onto the cleaned bottom and sides of the repair area before placing the hot open-graded bituminous mixture. Unless numerous, large-scale patches are being repaired at the same time, the open-graded bituminous mixture may be hand-placed and raked to an even level at 5- to 10-mm above the desired finished surface. For relatively large repair areas, it is best to place the hot open-graded bituminous materials with a standard asphalt paver to the same level slightly above the surrounding pavement surface. Compaction of the hot open-graded bituminous mixture is accomplished by 3 to 5 passes of a hand-operated vibratory plate compactor or 2 passes of a 2- to 3-tonne steel wheel roller in the static mode. Once the open-graded bituminous material has cooled to less than 38 deg. C, the resin modified grout is poured onto the repair area, being careful not to spill the grout outside of the repair area. The same vibratory equipment used to compact the open-graded bituminous material is used to vibrate the grout into the open-graded material immediately after grout application. Once the repair area is filled with grout, a curing compound is sprayed onto the surface in the same manner and application rate as specified for original RMP construction. The RMP patch can accept foot traffic the day after construction and light automobile traffic after three days. An RMP patch is considered full-strength 14 days after construction in relatively warm and dry environments and 21 days after construction in relatively cool and/or wet environments.

When the RMP and AC layers are removed, the surface materials used in the patch may be RMP over AC (identical thicknesses to the original pavement section) or traditional PCC materials. If the RMP over AC approach is used, the AC material must be of the same general quality and formulation as the AC used in the original design. The RMP layer is then placed in the same manner as previously described for a shallow RMP patch. Traditional PCC materials may be used to patch RMP repair areas when placed at a minimum depth of 100 mm and in patch surface areas no greater than 6 sq m. When the patch surface area is 1 sq m or less, then PCC materials are placed in the normal manner except that no bonding agents are used. When the patch surface area is between 1 and 6 sq m, then joints must be formed between the PCC patch and the surrounding RMP and AC pavement layers. The joints can be formed in place during patching or saw cut as soon as possible after patching. The joints should have a minimum width of 10 mm, follow other standard PCC joint geometric provisions, and should be filled with joint sealant materials previously described in this document for joint sealing.

The four RMP patching options discussed here are shown in the pavement profiles of Figure 2.2.

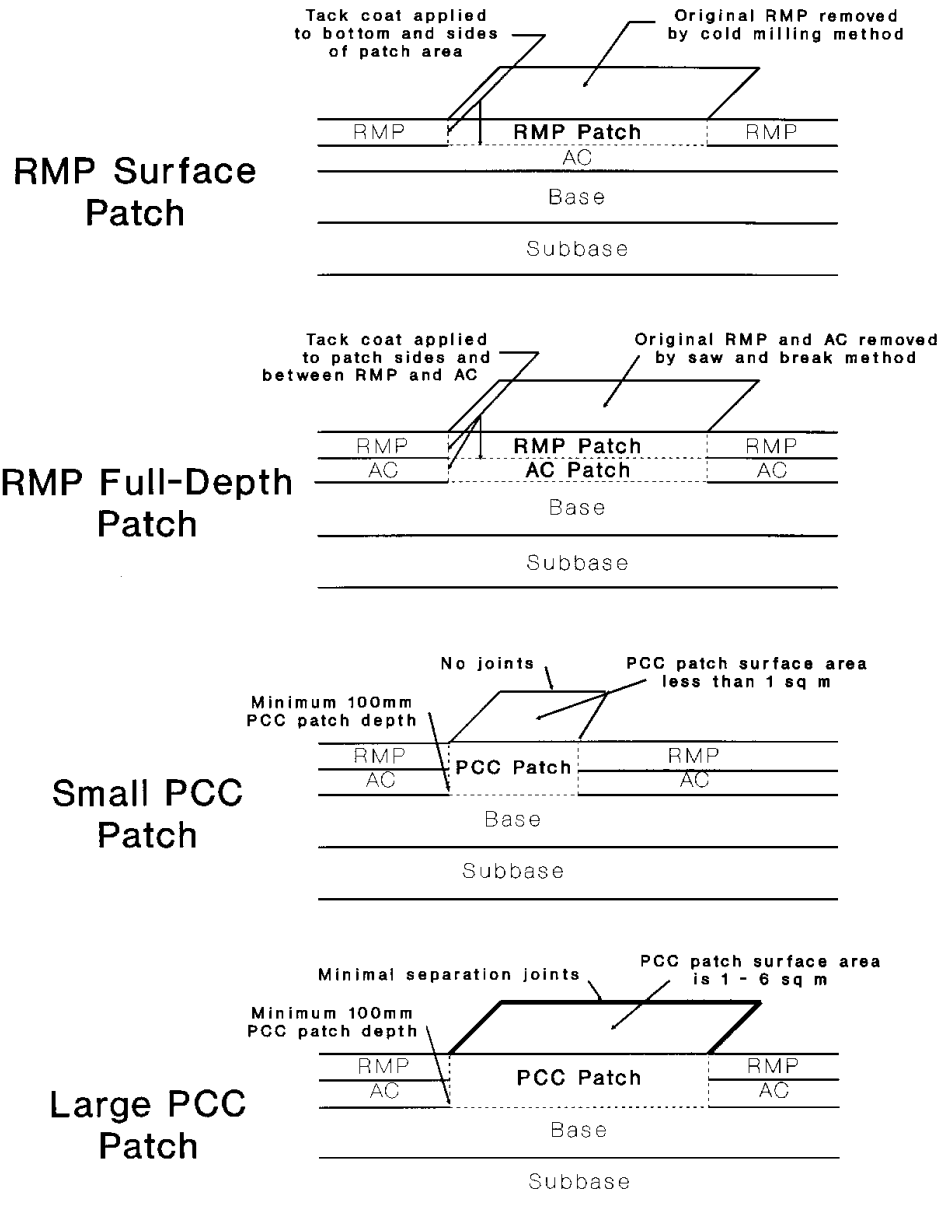


Figure 2.2. General pavement profiles of RMP patching options

## **Grooving**

The skid resistance of properly-constructed RMP has been found to be suitable for high-speed airfield traffic, with friction properties comparable to traditional PCC and AC pavement surfacings. It is possible, however, that the skid resistance of RMP may fall below desirable standards due to problems such as weathering, polishing aggregates, or improper construction techniques. A pavement rehabilitation technique which may be used to improve RMP skid resistance is grooving.

Grooving is the construction of a series of small grooves or cuts in the pavement surface, usually about 6-mm-wide by 6-mm-deep and spaced about 38 mm apart. The grooves are saw cut across the full width of the airfield pavement and transverse or perpendicular to the normal direction of traffic. In the case of new pavements, RMP should be cured at least 21 days after grouting before grooving takes place. Grooving of RMP should otherwise follow the guidance set forth in CEGS-02981 "Grooving for Airfield Pavements."